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NHTSA 03-14345-6

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EXECUTIVE SECRETARIAT

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NATIONAL HIGHWAY
TRAFFIC SAFETY ADM.

April 1, 2003

Dr. Jeffrey W. Runge, Administrator
National Highway Traffic Safety Administration
400 Seventh Street SW
Washington DC 20590

Re: A Petition for Rulemaking to Amend the testing requirements of FMVSS213 Child Restraint Systems, to require rear facing infant restraints to meet additional biomechanical requirements during dynamic sled testing.

Dear Dr. Runge:

XSci has performed exhaustive research and development in the area of infant seat design. Routinely, fully instrumented CRABI 6 month, TNO 9 month, and CRABI 12 month dummies are utilized to monitor the infant seat performance. The CRABI dummies are especially useful as they are most anthropomorphically representative of the infant, and are able to give the most extensive output data available to date. Much research has been accomplished in establishing a "criterion" for these dummies when used rear facing in a typical 213-test pulse. NHTSA reports "Development of Improved Injury Criteria for the Assessment of Advanced Automotive Restraint Systems - II" and "Techniques for Developing Child Dummy Protection Reference Values" are excellent references summarizing the significant development of these criterion. Important to XSci and pediatricians is Dr. John Melvin's SAE paper 950872, "Injury Assessment Reference Values for the 6-Month Infant Dummy in a Rear-Facing Infant Restraint with Airbag Deployment", in which he establishes criterion for the six month CRABI dummy, numbers for which are listed in Table 1. His development is most important regarding the neck limits and head accelerations involving the 6 month CRABI. The research he employs significantly relies upon tests performed on stillborns regarding neck tension and scaling from existing accident data. Under extreme loading conditions XSci has been able to consistently obtain test results without violating these limits (for the 6 month and 12 month CRABI test dummies). These extreme conditions are airbag interaction, and barrier contact.

The current and proposed FMVSS 213 test requires the infant cradle to be pivoted about the bite of the automotive seat with no obstructions inhibiting this rotational movement at all. In the case of the small infant cradles this rotational test represents the real world automobile environment. However, for the larger convertible restraints (infant to 3 year old capacity) and or the larger infant restraints such as the Pioneered II™ XSci manufactures, this approach is totally unrealistic. These larger restraints do contact some obstruction in their rotational movement in real world environments. Further in these conditions the convertibles typically will meet all established neck criterion, but exceed the acceleration limits to the head and chest established by Melvin and proposed by NHTSA due to hard contact. The Pioneered II™ easily meets the entire aforementioned criterion. In fact our neck numbers drop considerably in the extreme impact scenarios. This is due to the lack of rotation allowed either by hard barrier contact or airbag contact, real world boundary conditions. In basic terms the infant's back is kept more vertical, decreasing F_z significantly and therefore dropping N_y in the range of 0.4 to 0.7. What should be established is a guideline much like the ECE R-44 requirements. If the restraint passes a vertical plane established some distance away from the bite of the seat, than the restraint must pass impact requirements for the head and chest in addition to N_y and neck maximums.

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What causes the Nte to be such a challenge for rear facing infant seats in the 213-test environment is the large degree of free rotation. Essentially, the problem may be modeled as a compound pendulum with spring dampening. The first mass represents the infant's chest and the second the cg of the head. As the onset of acceleration loading occurs, the head G's are lower than the chest G's setting up shear, Fx. As the rotation peaks in the unimpeded rotation the head imposes a large tensile load to the neck. The Fz component is very high and combined with the Fx component Nij typically exceeds unity. Compounding Nij is neck extension moment at the acceleration peak.

NHTSA has employed exhaustive researched in the establishment of the Nij value starting at 1.4 and dropping the proposed requirement to 1.0. XSCi has developed an approach for meeting this requirement at a very low cost. Simply put we reduce the Fx and Fz components. Nij should remain as proposed 1.0. Additionally, Melvin's criterion should be adopted as part of the requirement for rear facing infant seat certification. The Melvin criterion for the 6 Month CRABI maintains limits for shear, tension, compression, flexion, and extension regarding the neck load cells. Developmentally, the 6-month infant has lower head neck strength and therefore this readily available and established research should and can be employed to ensure the survival of infants in rear facing restraints. Listed below in Table 1 are criterions that should be employed to best ensure the safety of the infant and can be practicably employed in any rear facing restraint under the proposed 213 acceleration curve.

TEST REQUIREMENTS	Peak Head G	HIC ₁₅	HIC ₂₂	HIC ₃₆	N _{ij}	Neck Flexion Forward My	Neck Tension	Neck Shear Force	Neck Exten Backward My	Neck Compression	Peak Chest G
213	1.0	100	100	100	1.0	1.0	1.0	1.0	1.0	1.0	1.0
213	1.0	100	100	100	1.0	1.0	1.0	1.0	1.0	1.0	1.0
213	1.0	100	100	100	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Table 1

Sincerely,

David Clement, PE
Director of Engineering / Technologies